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(54) **VENTILATOR**

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F24F 7/08	(2006.01)
F04D 25/08	(2006.01)
F04D 17/16	(2006.01)

(52) **U.S. Cl.**
CPC ***F24F 7/08*** (2013.01); ***F04D 17/16*** (2013.01); ***F04D 25/08*** (2013.01); ***F04D 25/088*** (2013.01); *F24F 2221/14* (2013.01)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

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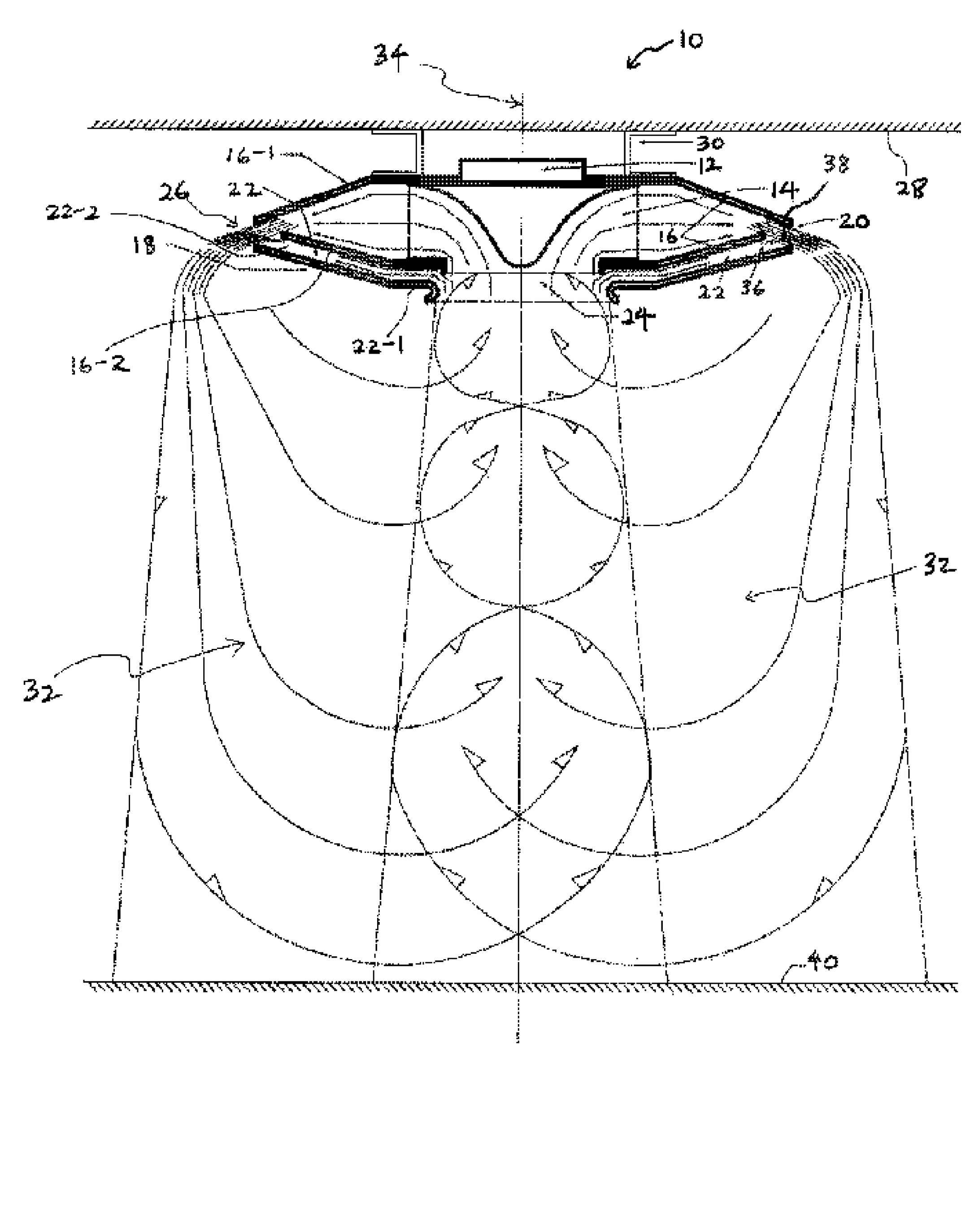
(57) **ABSTRACT**

A ventilator comprising an air blower; a casing comprising a first wall and a second wall configured to house the air blower centrally and to define a radially decreasing volume therebetween, a circumferential gap between the first wall and the second wall configured to allow a high velocity air stream to exit and to spiral in a direction away from a structure to which the ventilator is configured to be mounted, and a central opening in the second wall configured as a suction inlet of the air blower; and a flow amplifier adjacent the casing and configured to amplify air flow through an air flow passage defined between the flow amplifier and the second wall of the casing.

10 Claims, 3 Drawing Sheets



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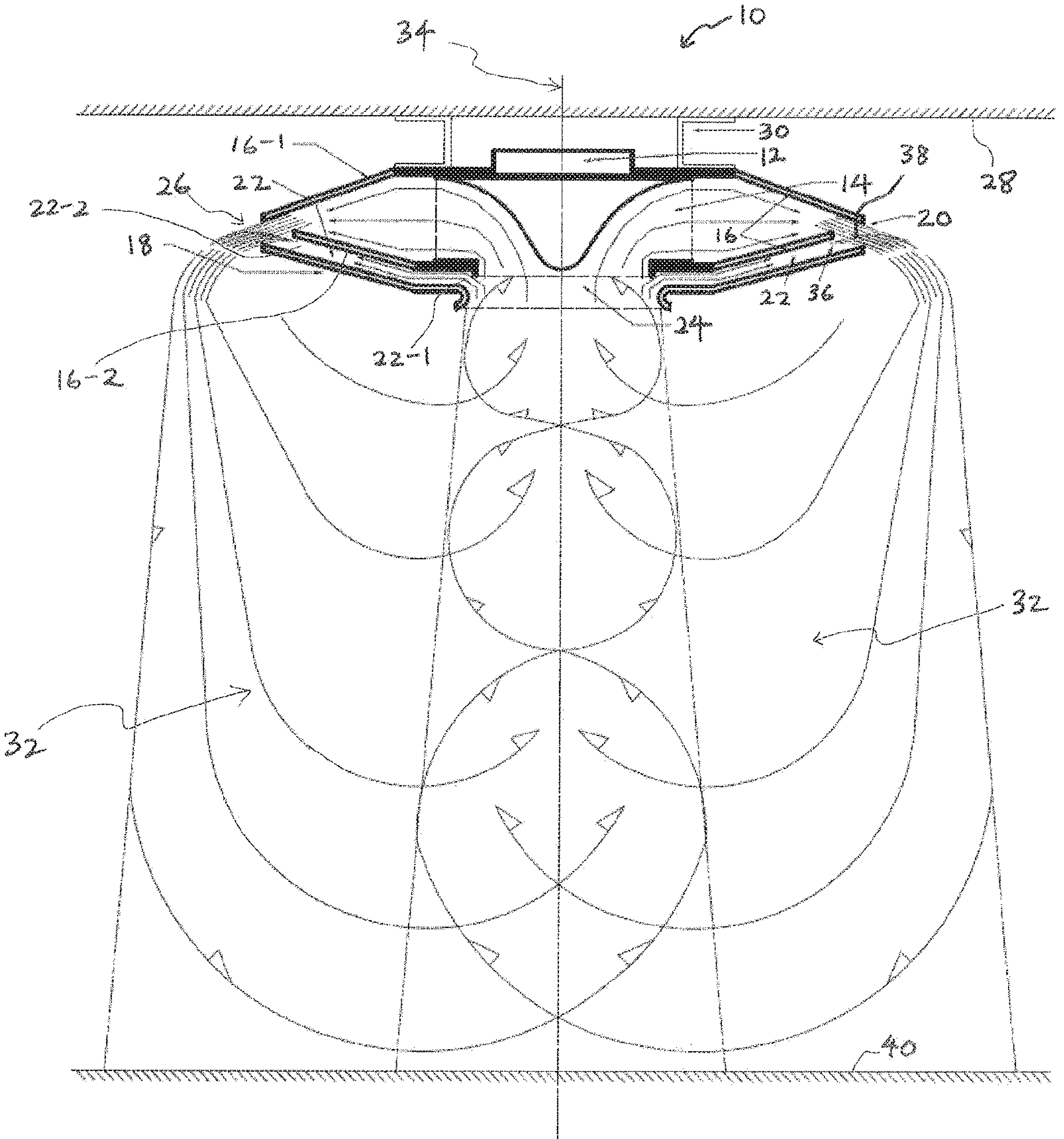
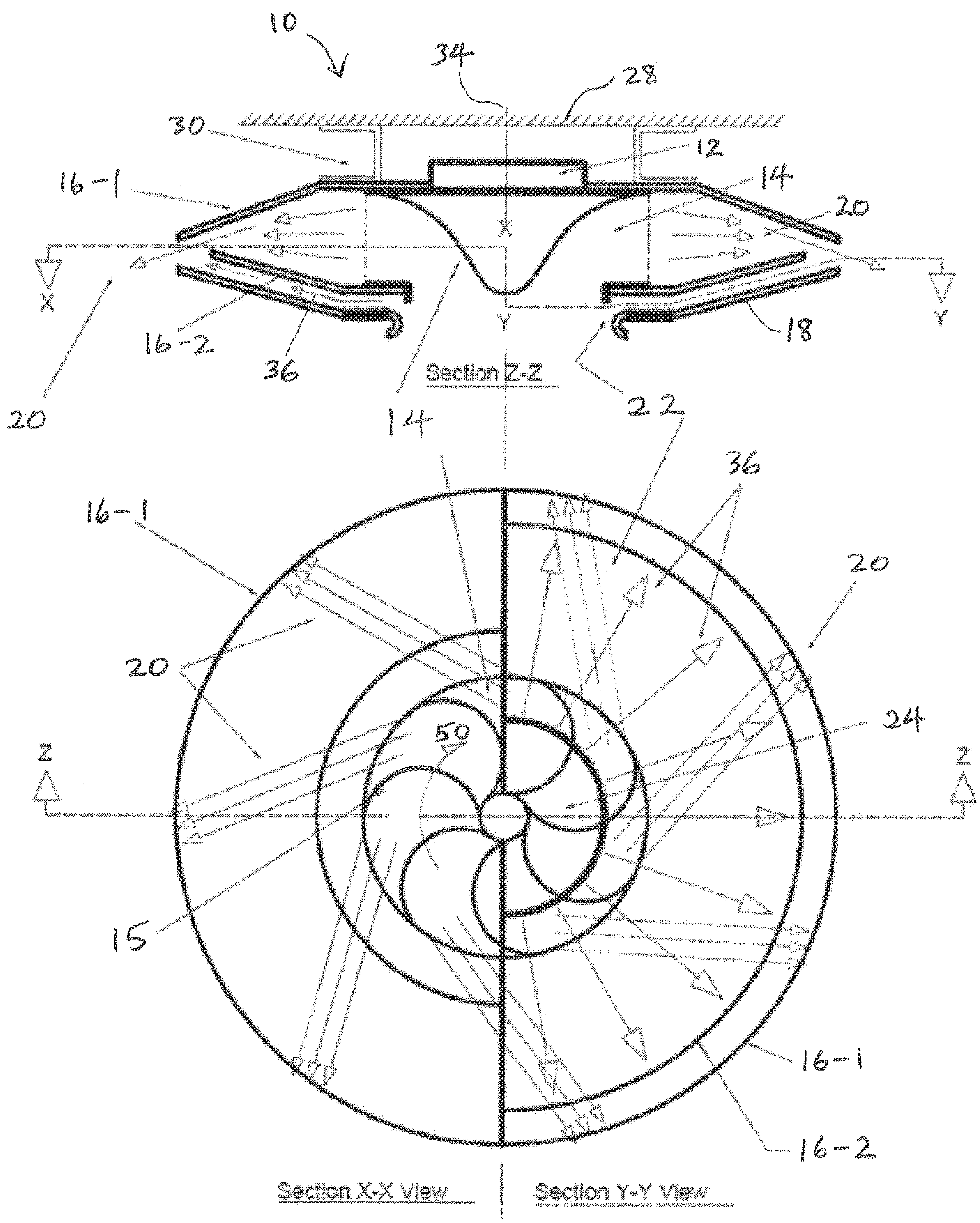


FIG. 1


10
34
28
30
12
16-1
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X
X
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16-2
36
18
Section Z-Z
20
14
22
36
16-1
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20
Z
50
24
Z
15
16-1
16-2
Section X-X View
Section Y-Y View

FIG. 2

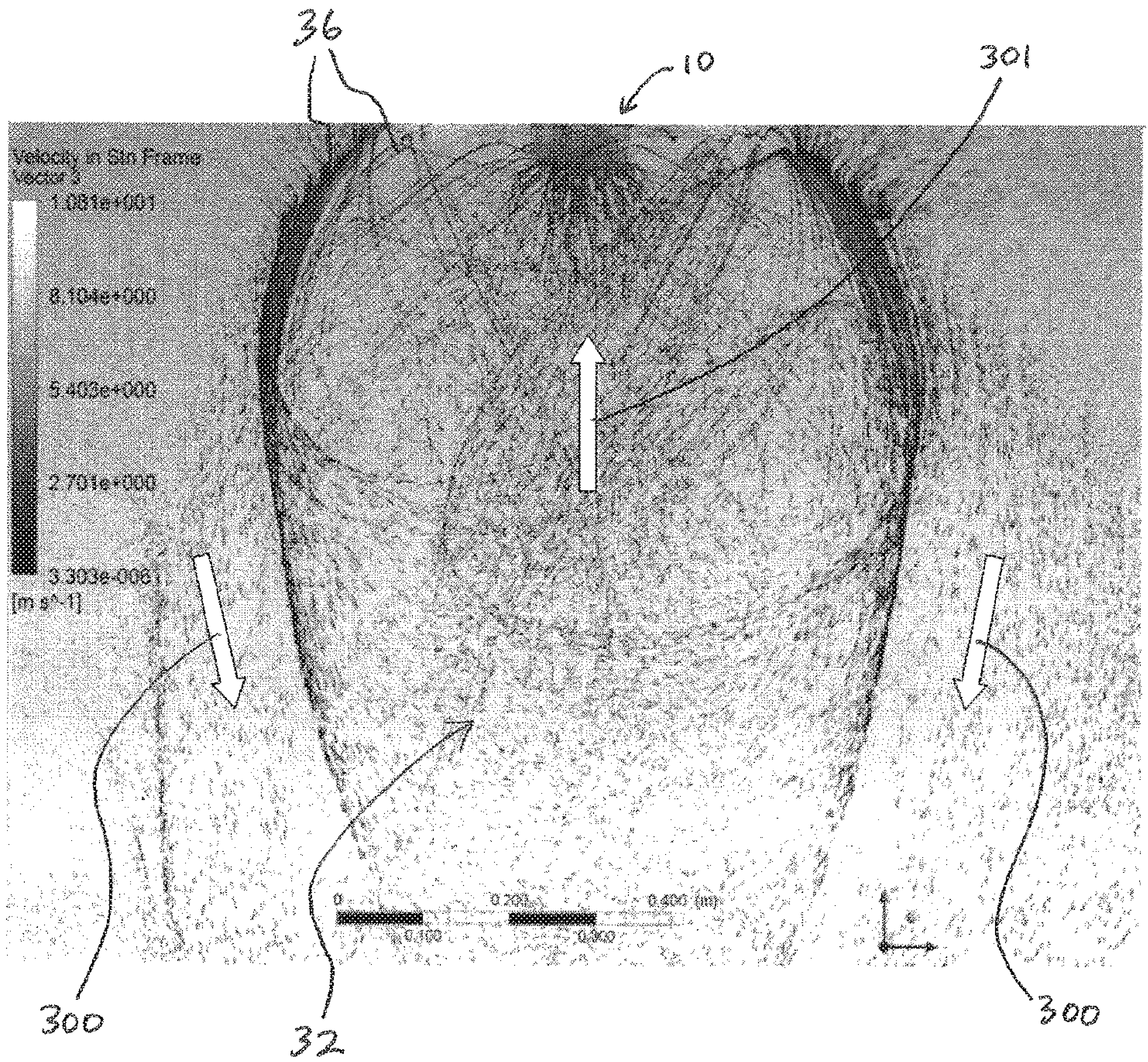
36
10
301
Velocity in Stn Frame
Vector 3
1.081e+001
8.104e+000
5.403e+000
2.701e+000
3.303e-006
[m s^-1]
300
32
300

FIG. 3

VENTILATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a filing under 35 U.S.C. 371 as the National Stage of International Application No. PCT/SG2014/000344, filed Jul. 18, 2014, entitled "A VENTILATOR," which claims the benefit of U.S. Provisional Application No. 61/856,192 filed on Jul. 19, 2013, both of which are incorporated herein by reference in its entirety for all purposes

FIELD OF THE INVENTION

This invention relates to a ventilator, in particular to a ventilator for ventilating/cooling a space.

BACKGROUND OF THE INVENTION

Current space cooling technologies employ an electric motor (dc or ac) to turn a set of blades that are inclined to their plane of rotation. The movement of inclined blades impinging on the column of stationary air provides pressurized air movement towards an object/person or surface to induce cooling by natural evaporation. These fan technologies can be ceiling-mounted, wall-mounted or standing, and air-flow is controlled by controlling speed of the motor. For wall-mounted and standing fans, air-flow direction can be oscillated by using another motor or reduction gear train to rotate the main motor blade assembly. However, ceiling-mounted units have fixed air-flow direction and air is directed from the top, i.e., the ceiling, to a user sitting below. Such bladed ceiling fans and wall-mounted fans have serious drawbacks and one of the disadvantages is the pushing of hot air from the ceiling to the user below. This technology has not changed since its invention some hundred years ago. This type of air movement is very energy inefficient aerodynamically.

Recent development in fan technology has resulted in a 'No Visible Blades" fan invented by Sir James Dyson and being sold under the same name. The Dyson fan with a blower concealed in the circular body of its stand forces pressurized air through an annulus slit near the leading edge of an aerofoil surface to draw secondary air. This type of fan has the advantage that it is perceived as 'Bladeless' and safe. Being a new product based on a novel concept, it is currently very expensive and comes as a standing fan design. The novelties are the use of the aerofoil to draw secondary air amplifying the total air-flow and the concealed blades design.

SUMMARY OF INVENTION

The present invention falls in the domain of space cooling and is based on a totally novel concept, namely, "Induced Vortex," mimicking the natural phenomenon of tornados but in a controlled manner to induce amplified air-flow for space cooling. In nature, hot air rises while cold air sinks. The invention lifts cold air from the floor level to be funnelled up, amplified and distributed over the user(s) or occupant(s) through an entirely new three-dimensional (3-D) vortex air flow pattern.

According to an exemplary aspect, there is provided a ventilator comprising an air blower; a casing comprising a first wall and a second wall configured to house the air blower centrally and to define a radially decreasing volume therebetween, a circumferential gap between the first wall and the second wall configured to allow a high velocity air stream to exit and to spiral in a direction away from a structure to which the ventilator is configured to be mounted, and a central opening in the second wall configured as a suction inlet of the air blower; and a flow amplifier adjacent the casing and configured to amplify air flow through an air flow passage defined between the flow amplifier and the second wall of the casing.

The air flow passage may have a constant flow cross section.

The flow amplifier may be configured such that during operation, negative pressure is felt at an inlet of the air flow passage and at an outlet of the airflow passage.

The flow amplifier may comprise a flow amplifying wall provided in parallel with the second wall of the casing.

The first wall, the second wall and the flow amplifying wall may be circular.

The flow amplifier may form a venturi with the first wall.

When the ventilator is oriented such that the first wall is above the second wall, an outer annulus of the first wall may slope downwardly in the radial direction and an outer annulus of the second wall may slope upwardly in the radial direction.

The first wall may have a greater diameter than the second wall.

The flow amplifier may be configured to mingle amplified air exiting the air flow passage with the high velocity air stream exiting the circumferential gap.

The high velocity air stream may have vorticity and direction controllable by a speed of the blower.

During operation, air may be drawn towards the suction inlet of the blower along a central axis of the ventilator.

The first wall may be configured for mounting the ventilator to the structure, the structure being at least one of: a ceiling, a wall and a stand.

BRIEF DESCRIPTION OF FIGURES

In order that the invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only exemplary embodiments of the present invention, the description being with reference to the accompanying illustrative drawings.

FIG. **1** is a schematic side view of the ventilator for space cooling;

FIG. **2** is a set of sectional views of the ventilator of FIG. **1**; and

FIG. **3** is a simulated computational fluid dynamics (CFD) air flow of the ventilator of FIGS. **1** and **2** in operation.

DETAILED DESCRIPTION

Exemplary embodiments of the invention will be described with reference to FIGS. **1** to **3** below.

The vortex ventilator **10** comprises an electric motor **12**, preferably dc-brushless, driving an aerodynamically efficient back swept design **15** air blower **14** encased in a circular but radially narrowing casing **16**. The air blower **14** comprises a plurality of back-swept blades **15** with reference to the direction of rotation as shown by arrow **50** in FIG. **2**. The blower **14** is located centrally within the casing **16**, and is configured to blow air in a radial direction.

The casing **16** comprises a circular first wall **16-1** and a circular second wall **16-2** having a common central axis **34** and configured to house the blower **14** centrally therein and to define a radially decreasing volume between the first wall

16-1 and the second wall **16-2**. The first wall **16-1** is configured for mounting **30** the ventilator **10** to a ceiling **28** or other appropriate structure. In one embodiment when the ventilator **10** is oriented such that the first wall **16-1** is above the second wall **16-2**, as shown in FIGS. **1** and **2**, the first wall **16-1** is configured as a circular upper or top wall **16-1** having an outer annulus sloping downwardly in the radial direction while the second wall **16-2** is configured as a circular lower or bottom wall **16-2** having an outer annulus sloping upwardly in the radial direction. Central portions of the first wall **16-1** and the second wall **16-2** preferably remain in the horizontal plane.

Outer rims of both the first wall **16-1** and second wall **16-2** are spaced apart from each other, thereby defining a circumferential gap **26** in the casing **16** to allow the exiting of high velocity air stream **20** from the casing **16**, as generated by the blower **14**. The circumferential gap **26** is configured such that the high velocity air stream **20** exits the casing **16** and spirals in direction away from ceiling or other structure to which the first wall **16-1** is mounted, thereby inducing a 3D vortex. Where the ventilator **10** is mounted to a ceiling **28**, the high velocity air stream **20** exits the casing at a downward angle to the horizontal plane as well as in a spiral flow downward, resulting in a spiralling down draught indicated by arrows **300** in FIG. **3**. This may be achieved, for example, by configuring the circular first wall **16-1** to have a greater diameter than the circular second wall **16-2** as shown in FIGS. **1** and **2**. The second wall **16-2** is provided with a central circular opening **24** to serve as a suction inlet **24** of the blower **14**. The casing **16** thus acts as an air collector through the suction inlet **24** as well as a circumferential venturi **26** via the circumferential gap **26**.

Arranged adjacent to the casing **16**, in parallel with the second wall **16-2**, is another circular wall or flow amplifying wall **18** defining an annular air flow passage **22** of constant flow cross section that is parallel with the second wall **16-2**. Similar to the second wall **16-2**, the flow amplifying wall **18** has a central opening to allow air passage into the suction inlet **24** of the blower **14**. The flow amplifying wall **18** serves as a flow amplifier to amplify flow **36** through the air flow passage **22**. The flow amplifying wall **18** connects the circumferential annulus venturi **26** with the suction opening or suction inlet **24** of the blower **14**.

In the embodiment shown in FIGS. **1** and **2**, the flow amplifying wall **18** is circular and forms a venturi with the first wall **16-1** so that part of the total energy is converted to velocity at the venturi throat **38** and consequent negative pressure at the throat **38**. Reduction in static pressure at the throat **38** thus draws additional air through passage **22**, resulting in amplified flow **36** exiting the air flow passage **22** that mingles with the high velocity air stream exiting the circumferential gap **26** of the casing **16**.

The ventilator **10** may be mounted onto a ceiling **28** by means of mounting brackets provided between the first wall **16-1** of the casing **16** and the ceiling **28**.

Electrical energy supplied to the motor **12** is converted into kinetic energy in the form of the high velocity air stream **20** generated by the blower **14** and discharged uniformly through the annulus venturi **26**. This high velocity spiralling but downward flowing air stream **20** is the induced three-dimensional (3-D) vortex **32** whose vorticity and direction are controllable by the speed of the blower **14** and/or by iris shutters (not shown) as an option.

As the air hits the floor **40**, lower pressure created at the suction inlet **24** of the blower **14** will help to sustain negative pressure in the core of the 3-D vortex **32** that is along the central axis **34** of the ventilator **10**, but with a change in direction upwards, resulting in a spiralling up draught as indicated by arrow **301** in FIG. **3**. The positive feedback of air flow back upwards along the central axis **34** to the blower **14** further helps to sustain the continuous flow of the vortex **32**. This change in direction of the vortex **32** and positive feedback is the essence in this invention that gives rise to a more effective low-cost natural cooling and the optimisation of the blower **14** performance.

Negative pressure at the blower inlet **24** will also be felt at the start **22-1** of the air flow passage **22** (at the central opening of the circular wall **18**) communicating with the venturi annulus **26**. Similar negative pressure will also be felt at the end **22-2** of the flow passage **22**. These differential pressures induce air flow through the flow passage **22** but at a higher magnitude as compared to that of the air flowing through the blower **14**. This is the novel dynamic of flow amplification **36**. This amplification **36** reduces the energy needed to sustain the upward draft and the downward draft of the vortex **26**. This together with the electronically controlled dc-brushless motor **12** allow the vortex ventilator **10** energy consumption to be minimized under various operating/load condition.

The profile and the strength of the vortex **32** are determined by the design of the motor **12**, the casing blower **14** and the casing **16**. The flow amplification is determined by the design and positioning of the flow passage **22**. In this ventilator, unlike a conventional space cooling fan system, the foot print of the air flow does not depend on the enclosure like walls; instead, cool air is drawn from ground level **40**, amplified and distributed without mixing with the strata of hot air just below the ceiling **28** or just above the vortex ventilator **10**.

In addition, by incorporating optimally designed guide vanes (not shown) in the venturi annulus **26** and circular "Iris" shaped louvers (not shown) at the periphery of the venturi annulus **26**, it would be possible to control the vortex envelop in profile and strength to a small foot print similar to localised personal lighting.

By shape and design, the vortex ventilator **10** lends itself to fit ceiling lights (both pendant and down lights), air ionizing electrodes, heating coils (electric), Peltier effect (for cooling) elements, etc., integral with the unit and rotating elements totally sealed from harm's way. The final commercial product will include the necessary embedded controls and remote operability for comfort and energy efficiency.

Significant novelties of this invention are (i) the design of an air handling system **10** to bring about a controlled three dimensional vortex **32** generation that can lift cooler air from the floor level **40** and distributing it evenly onto occupants below to induce evaporative cooling; and (ii) to convert some of the kinetic energy of the air flowing through the blower unit **14** into negative pressure to induce parallel air flow of several magnitudes, thus achieving air flow amplification **36** and better air flow gain per kilowatt hour electrical energy used.

Unlike conventional ceiling fans which can only force hot air from the top onto the occupant and relying on the room geometry to circulate the internal air, this invention allows air to be circulated in a controlled vortex manner regardless of the room or space geometry. It is hence also suitable for outdoor applications. Another novel feature of this invention is its ability to control the vortex area foot print to concentrate the cool air onto a small foot print (group of users) or a larger foot print (bigger group of users). This flexibility leads to energy saving as the output power of the motor can be substantially reduced by this innovative means of channelling the air-flow via the vortex to a dedicated area. This invention allows energy efficient dedicated cooling similar to that of dedicated task lighting. The ventilator **10** not only sucks in the cool air from the vortex but also amplifies the air flow many times, drawing more cool air outside the eye of the upward draft of the inner core of the three dimensional vortex **32** and throwing the cool air onto the downward draft of the same vortex **32**, increasing the air handling efficiency of the overall system **10**.

As add-ons, it is possible to integrate ceiling lights (pendant and down lights), air ionizing electrodes, heating coils (electric), Peltier effect (for cooling) elements, etc., without shadow effects and for a more uniform and natural dispersion effect respectively.

Advantages of the present invention and improvements over existing space cooling methods and devices are given below:

- More energy efficient natural cooling system.
- Controllable cooling space (volume) foot print.
- Can be integrated with modern cooling systems such as active-chilled beam and cool ceiling for air-conditioning
- Suitable for both indoor and outdoor use—does not depend on space geometry.
- Allows air stratification—does not blow down hot air unlike conventional fans.
- Better air flow distribution and cooling effect (rotating air draft as compared to direct) than existing bladed fans.
- Space lighting can be integrated without shadow effect
- No exposed rotating parts, hence safer than existing ceiling fans
- Flexible to add optional features without affecting the original function
- No height constraints in deployment

Commercialization of this invention is targeted at the tropical ceiling fan markets as well as at outdoor applications like food courts and hawker centres. The scalability and flexibility of the invention also allow smaller systems scaled to suit personalized targeted cooling as in the case of car interiors or as a hybrid table lamp cum space cooling/heating or as a hybrid task lighting and local space cooling/heating. The invention can create air stratification, lifting cool air from lower levels to the level of the blower, hence allowing the system to be installed at any height. As the system does not have exposed rotating parts, unlike that of conventional ceiling fans, proximity of the blower unit **14** is not a serious safety issue and hence would be ideal for low ceiling tropical flats and apartments. This invention can be applied as designer lighting with cooling gadget for interior decoration and design suitable for homes and commercial buildings since both pendant lighting and down lighting can be integrated with the vortex ventilator **10** without shadowing effects. For large space cooling and air-conditioning applications, this invention can be easily incorporated into the latest active chilled beam and cool ceiling technologies. It can also be hung over a small pond or fountain to induce further cooling effect from evaporative cooling generating a gentle spiralling breeze in gardens and other similar settings. Where appropriate, it can also be mounted on a wall or even as a standing unit to exploit the spiralling gentle breeze generated by the vortex ventilator **10** to pick up the cooler air near the surface.

Whilst there has been described in the foregoing description exemplary embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations in details of design, construction and/or operation may be made without departing from the present invention. For example, while a back swept design air blower has been described, blowers having other designs may be used. Other possible variations include blowers with forward swept, straight vanes, complex vanes involving straight and curve vanes, and compound vanes.

The invention claimed is:

1. A ventilator comprising:

an air blower;

a casing comprising

a first wall and a second wall configured to house the air blower centrally and to define a radially decreasing volume therebetween,

a circumferential gap between the first wall and the second wall configured to allow a high velocity air stream to exit and to spiral in a direction away from a structure to which the ventilator is configured to be mounted, and

a central opening in the second wall configured as a suction inlet of the air blower; and

a flow amplifier adjacent the casing, the flow amplifier comprising a flow amplifying wall provided in parallel with the second wall of the casing and is configured to amplify air flow through an air flow passage defined between the flow amplifying wall and the second wall of the casing.

2. The ventilator of claim **1**, wherein the air flow passage has a constant flow cross section.

3. The ventilator of claim **1**, wherein the first wall has a greater diameter than the second wall.

4. The ventilator of claim **1**, wherein the flow amplifier is configured to mingle amplified air exiting the air flow passage with the high velocity air stream exiting the circumferential gap.

5. The ventilator of claim **1**, wherein the high velocity air stream has vorticity and direction controllable by a speed of the blower.

6. The ventilator of claim **1**, wherein, during operation, air is drawn towards the suction inlet of the blower along a central axis of the ventilator.

7. The ventilator of claim **1**, wherein the first wall is configured for mounting the ventilator to the structure, the structure being at least one of: a ceiling, a wall and a stand.

8. The ventilator of claim **1**, wherein the first wall, the second wall and the flow amplifying wall are circular.

9. The ventilator of claim **8**, wherein the flow amplifying wall forms a constricted section with the first wall.

10. The ventilator of claim **8**, wherein, when the ventilator is oriented such that the first wall is above the second wall, an outer annulus of the first wall slopes downwardly in the radial direction and an outer annulus of the second wall slopes upwardly in the radial direction.

* * * * *